Pete Cafferata
Drew Coe
California Department of Forestry and Fire Protection
Watershed Protection Program
April 24, 2018

The following are replies and comments related to questions posed by California Board of Forestry and Fire Protection (BOF) Member Mike Miles regarding the monitoring and research of Class II watercourses by the Effectiveness Monitoring Committee (EMC). The original email and questions are shown in the text box(es) below.

-------- Original message --------
From: Mike Miles <mmiles@hrcllc.com>
Date: 2/6/18 8:55 PM (GMT-08:00)
To: Sal Chinnici <SChinnici@hrcllc.com>, "Dias, Matt@BOF" <Matt.Dias@bof.ca.gov>, Matt House <MHouse@greendiamond.com>, "Coe, Drew@CALFIRE" <Drew.Coe@fire.ca.gov>, "Cafferata, Pete@CALFIRE" <Pete.Cafferata@fire.ca.gov>
Subject: Class II L Rule Effectiveness Study
Regarding Class II Watercourse Protection Studies

Public comment made at the last BOF meeting reminded the Forest Practice Committee that effectiveness monitoring studies of the Class II – Large watercourse rule should be designed to answer questions regarding the necessity and benefit of Class II–L riparian forest prescriptions relative to downstream receiving Class I waters; and what if any correlation in benefit is related to channel size and/or streamflow AND distance from receiving Class I waters. I recognize answering such questions is beyond the ability of any one study, however it is my hope that the EMC endorses studies on this subject matter that will shed light on these questions related to nutrient, sediment, large wood, and temperature transfer.

Below are some questions reflective of those that arose during the Class II-L prescription development dialogue. Studies designed to answer these types of questions will likely prove useful to the BOF and Forest Practice Rule making process as a whole. It has been awhile since I reviewed the current Class II-L study endorsed by the EMC but I suspect it addresses some or many of these questions. This area of scientific inquiry is complex and it is recognized that an array of focused technically sound studies over an extended period of time is necessary to provide confidence in determining what additional measures or other changes to current Class II Standard and Large watercourse prescriptions, if any, are necessary for the conservation and restoration of Class I streams relative to the ecological contribution of their Class II tributaries.

I share this in response to what I was reminded at the last BOF meeting during stakeholder comment and because it has been on my mind for several years. Please consider as you see fit.

Thank you
Mike

Example Questions:

1. Macroinvertebrates: Do Class II riparian forests with larger trees and greater canopy requirements like those required under Class II-L produce a greater quantity of aquatic macroinvertebrates than Class II riparian forests utilizing standard FPRs? (NECESSITY and BENEFIT)
2. Macroinvertebrates: Do Class II riparian forests with larger trees and greater canopy requirements like those required under Class II-L produce a greater quantity terrestrial macroinvertebrates than Class II riparian forests utilizing standard FPRs? (NECESSITY and BENEFIT)
3. Further study of maximum transport distance of macroinvertebrates from Class II waters to Class I waters. (CLASS II-L DISTANCE OF PROTECTION)
4. Temperature: Do Class II riparian forests with larger trees and greater canopy requirements like those required under Class II-L produce a measurable and significant (e.g. > 1 C° difference) reduction in Class II water temperature compared to Class II riparian forests utilizing standard FPRs? (NECESSITY and BENEFIT)
5. Temperature: If 4 above is true, what distance do Class II waters need to travel through Class II-L canopy conditions to achieve this reduction in water temperature? Does this distance vary in correlation to channel width or volume of flow (cfs)? (CLASS II-L DISTANCE OF PROTECTION; CLASS II-L MINIMUM CHANNEL SIZE)
6. Large Wood Recruitment: Does more LWD recruitment through bank erosion, windthrow, competition/mortality occur in Class II streams receiving Class II-L prescriptions than Class II-Standard Rx? (NECESSITY and BENEFIT)
7. Large Wood Recruitment: Does larger wood (>24 inch DBH) in Class II watercourses create greater habitat complexity, pool depths, and provide greater sediment storage opportunity store more sediment than smaller wood (<24 inch DBH)? (NECESSITY and BENEFIT)
8. Large Wood Recruitment: Do Class II watercourses with a bankfull channel width of less than 5 feet transport significant amounts of key piece size wood downstream to Class I waters (e.g. minimum 6" diameter x 1.5 length of receive Class I water channel width)? (CLASS L MINIMUM CHANNEL SIZE)
9. Do Class II watercourses with a bankfull channel width of 5-10 feet transport significant amounts of key piece size wood downstream to Class I waters (e.g. minimum 6" diameter x 1.5 length of receive Class I water channel width)? (CLASS II-L MINIMUM CHANNEL SIZE)

Replies and comments to Member Mile's questions were generated using the following information:

- Empirical results from peer reviewed literature;
- Empirical results from gray literature;
- Conceptual models from peer reviewed literature;
- Reasoned analysis from first principles.

In addition, we note when ongoing and/or proposed EMC work can potentially address specific questions, as well as limitations for designing studies to answer these specific questions.

<u>Question 1 – Aquatic Macroinvertebrates</u>: Do Class II riparian forests with larger trees and greater canopy requirements like those required under Class II-L produce a greater quantity of aquatic macroinvertebrates than Class II riparian forests utilizing standard FPRs? (NECESSITY and BENEFIT).

<u>Reply:</u> There are no specific examples of this question being addressed in the published or unpublished literature. Specific to California, Wilzbach et al. (2005), the Sound Watershed TAC report (SWC 2008), Wilzbach and Cummins (ND), and the GDRCo Section V Ah Pah study (in progress) provide information on the benefit of <u>more light</u> (not less) producing higher levels of primary productivity, and potentially greater salmonid production. Kaylor and Warren (2017) present similar data for western Oregon. Erman and Ligon's (1986) JDSF algal study found more nuisance filamentous algae in a logged Class I than in an unlogged Class I watercourse. Newbold et al. (1980), Mahoney and Erman (1984), and Erman et al. (1977) showed value of 30 m buffer strips for macroinvertebrate communities.

The Hinkle, Trask, and Alsea watershed studies in western Oregon (Li et al. 2013) have produced data illustrating that although benthic invertebrate densities increased at headwater sites post-harvest, there were no detectable density differences at mainstem sites. Prey consumption by trout, whose densities at mainstem sites increased following harvest, possibly explained the lack of change observed for invertebrate densities. Wipfli and Gregovich (2002) published a relevant paper documenting the transport of macroinvertebrates from non-fish streams to fish bearing streams in Alaska, stating: "We predict that partial or complete riparian forest canopy removal will initially provide less allochthonous inputs and more autochthonous production (because of increased solar radiation) in these small streams (Fisher & Likens, 1973; Gregory et al., 1987; Hetrick et al., 1998). We also predict that harvesting practices that remove fewer trees per stand will cause smaller shifts (less amplitude and shorter duration) in energy pathways than harvesting scenarios that remove more timber. Some of these 'intermediate' alternative strategies (i.e. versus no cutting or clearcutting) may actually increase headwater productivity and downstream material transport, provided the physical integrity of these systems is not compromised, as streams receive increased solar radiation while sustaining some level of allochthonous inputs from the riparian trees and understory plants that remain. However, timber harvesting may also increase soil erosion and sedimentation (Waters, 1995), which may ultimately obliterate biological responses."

In western British Columbia, Yeung et al. (2017) showed a higher density of shredders in reference and thinned (50% basal area reduction) reaches versus reaches that were clearcut or had 10- or 30-m fixed width riparian reserves. Richardson and Béraud (2014) performed a meta-analysis on the effects of riparian forest harvest on streams, and found that the total density of invertebrates was significantly higher after riparian logging (n=18 replicated studies), and the treatment effects were highest in steeper streams (> than 10 percent stream gradient).

This question can potentially be answered by the Class II Prescription Effectiveness study, which is in development with Green Diamond Resource Company, Oregon State University, and CAL FIRE.

<u>Question 2 – Terrestrial Macroinvertebrates</u>: Do Class II riparian forests with larger trees and greater canopy requirements like those required under Class II-L produce a greater quantity terrestrial macroinvertebrates than Class II riparian forests utilizing standard FPRs? (NECESSITY and BENEFIT)

Reply: There are no specific examples of this question being addressed in the published or unpublished literature. Hardy's (2017) Master of Science thesis and PowerPoint provides information on terrestrial nutrient inputs to Class I and Class II watercourses in Little Creek, Swanton Pacific Ranch in the Santa Cruz Mountains. He found that the macroinvertebrate communities in study reaches were predominantly structured by the availability of detrital-based food resources (allochthonous input derived from outside the system). Hess' (1969) Caspar Creek Master of Science thesis on terrestrial insect input in South Fork Caspar Creek reported a significant increase in total insect numbers occurred in areas which had considerable streamside disturbance resulting in canopy removal.

This question could be nested within the Class II Prescription Effectiveness study, but would add additional cost and complexity to what is already proposed.

<u>Question 3</u> – **<u>Transport of Macroinvertebrates from Class II to Class I watercourses</u>**: While not framed as a question in Member Mile's email, he suggests more study is needed of transport distances, specifically maximum distances from Class II waters to Class I waters. (CLASS II-L DISTANCE OF PROTECTION)

Reply: There appears to be limited data on transport distance in the literature. Svendsen et al. (2004) suggest average daily travel distances ranging from 1 to 10 m, with less frequent values of approximately 50 m day^{-1}. Overall, they reported that (1) the spatial and temporal scales of drift vary considerably between stream systems and seasons, and (2) the often fishless steep headwater streams of mountainous regions may provide large quantities of nutrient rich exports to downstream fish bearing streams from macroinvertebrate drift. Wilcox et al. (2008) found that more turbulence (i.e., higher Reynold's number) resulted in more macroinvertebrate drift, and large woody debris (LWD) can affect turbulence in headwater streams.

<u>Question 4 – Buffer Conditions and Temperature</u>: Do Class II riparian forests with larger trees and greater canopy requirements like those required under Class II-L produce a measurable and significant (e.g. > 1 C difference) reduction in Class II water temperature compared to Class II riparian forests utilizing standard FPRs? (NECESSITY and BENEFIT)

Reply: There is nothing this specific in the literature. Most studies have examined the difference in temperature response for buffered versus unbuffered streams, and do not look at relatively small variations in canopy cover. Examples of past and current studies conducted in northwestern California include Roon (2018), Wick (2016), and Cafferata (1990). MacDonald and Coe (2007) summarize the broader literature on this topic.

Otis' (2007) OSU Hinkle Creek temperature thesis reported: "At 300 meters, nominally, downstream of the harvest units the impact of timber harvest on MDST was not statistically significant for two streams and only moderately statistically significant for the other two streams" (see also Otis and Skaugset 2007). Kibler's (2007) OSU thesis at Hinkle Creek is also relevant to this question. She reported that "Change detection analyses that considered the mean response among all four harvested streams indicated that maximum daily stream temperatures did not increase after harvesting, but that minimum and mean daily temperatures <u>decreased</u> significantly after harvesting. Additionally, diel stream temperature fluctuations were significantly greater one year after harvesting. Pre- and post-harvest surveys of canopy closure in the harvested and unharvested streams were completed in order to compare levels of stream shading before and after harvest. The post-harvest survey quantified canopy closure from remaining overstory vegetation as well as from logging slash that partially covered the harvested streams. The surveys indicated that mean overstory canopy closure in the harvested streams decreased by 84% as a result of the harvest, but as the logging slash provided considerable cover, total canopy closure decreased by only 20%. It is possible that the logging slash effectively attenuated solar radiation and prevented extreme temperature increases in the harvested streams. However, <u>it is likely that streamflow increased after harvesting and that the increased streamflow also prevented increases to maximum temperatures</u> and contributed to lower minimum and mean stream temperatures." [emphasis added]

Kibler et al. (2013) reported on harvesting treatments to four headwater tributaries of Hinkle Creek, designed in accordance with the Oregon Forest Practices Act. Therefore, fixed-width buffer strips containing overstory merchantable trees were not left adjacent to the four non-fish-bearing streams. The summer following harvesting, they observed a variable temperature response across the four harvested streams. <u>Mean maximum daily stream temperatures ranged from 1.5 C cooler to 1.0 C warmer relative to pre-harvest years.</u> They also observed significantly lower minimum and mean daily stream temperatures, and recorded particularly low temperatures in treatment streams on days that minimum stream temperatures in reference streams were high. At the watershed scale, they did not observe cumulative stream temperature effects related to harvesting 14% of the watershed area in multiple, spatially-distributed harvest units across four headwater catchments.

Bladon et al. (2018) showed that lithology can influence the susceptibility of a stream to harvest-induced thermal impacts, with more resistant lithologies being more prone to temperature increases. The authors attributed this to the moderating effect of groundwater in more friable (i.e., less resistant) lithologies. Moore et al.'s (2005) review of stream temperature response to forest harvesting stated that, "For the studies where similar metrics were available (e.g., maximum summer temperature), treatment effects exhibited substantial variability, even where the treatments appeared to be comparable (e.g., HJA Watershed 1 and Needle Branch)." This indicates that detecting temperature changes due to relatively minor changes in buffer characteristics might be difficult.

The Class II Prescription Effectiveness Study will look at water temperature response to changes in canopy cover and buffer width.

Question 5 – Longitudinal Buffering of Temperature: If 4 above is true, what distance do Class II waters need to travel through Class II-L canopy conditions to achieve this reduction in water temperature? Does this distance vary in correlation to channel width or volume of flow (cfs)? (CLASS II-L DISTANCE OF PROTECTION; CLASS II-L MINIMUM CHANNEL SIZE)

There is nothing this specific in the literature. Otis' (2007) OSU thesis in Hinkle Creek suggests that at 300 meters, downstream of the harvest units the impact of timber harvest on MDST was not statistically significant for two streams and only moderately statistically significant for the other two streams. Bladon et al. (2018) found a rapid cooling of water temperature (i.e., 7-day average of maximum daily water temperature) below 100-500 m below harvest, but water temperatures still remained slightly elevated (< 1° C) as compared to reference reach. Davis et al. (2016) used Newton's law of cooling in a modeling framework and determined that temperature changes (i.e., harvest-induced water temperature increases) would be reduced 18-99 percent within approximately 300 meters downstream of the harvest.

Data from the Class II Prescription Effectiveness Study will examine the longitudinal buffering of water temperature.

Question 6 - Large Wood Recruitment: Does more LWD recruitment through bank erosion, windthrow, competition/mortality occur in Class II streams receiving Class II-L prescriptions than Class II-Standard Rx? (NECESSITY and BENEFIT)

There is nothing this specific in the literature. In a modeling study, Benda et al. (2016) suggests that in a thinned (i.e., approximately 60 percent reduction in stem density) Douglas-fir/western hemlock stand, a 33-foot core zone buffer preserved 93 percent of the recruited wood. This study indicated that LWD recruitment can be retained at a relatively high rate with substantial stem removal occurring approximately 30 feet from the stream channel. However, the proportion of large wood recruited to headwater channels by landslides and other mass wasting processes may be substantial, and originate from considerable distance from the channel. Currently, very little is known about the role of mass wasting in wood recruitment and storage relative to other processes, such as bank erosion and mortality, in larger streams (Hassan et al. 2007).

To specifically answer this question, a decadal-scale field study or a modeling study would need to be implemented. Stand data from the Class II Prescription Effectiveness study could be used in the modeling study.

<u>Question 7 - Large Wood Recruitment and Channel Process/Function</u>: Does larger wood (>24 inch DBH) in Class II watercourses create greater habitat complexity, pool depths, and provide greater sediment storage opportunity store more sediment than smaller wood (<24 inch DBH)? (NECESSITY and BENEFIT)

Reply: There is nothing this specific in the literature. Scott et al. (2014) showed that channel step height is a linear function of LWD diameter, suggesting that larger LWD diameter creates higher channel steps and a higher capacity for pool scour. Larger steps can store more sediment (Lancaster and Grant 2006), suggesting that channel steps formed by larger diameter LWD may increase sediment storage per unit length of stream. Jackson and Sturm (2002) reported that relatively small wood (diameters between 10 and 40 cm), inorganic material, and organic debris (diameters <10 cm) were major step-forming agents for Pacific Northwest headwater streams, while big woody debris pieces (>40 cm) created <10% of steps.

Specific answers to this question would require additional field study.

<u>Question 8 – Transport of LWD</u>: Do Class II watercourses with a bankfull channel width of less than 5 feet transport significant amounts of key piece size wood downstream to Class I waters (e.g. minimum 6" diameter x 1.5 length of receive Class I water channel width)? (CLASS L MINIMUM CHANNEL SIZE)

There is nothing this specific in the literature. However, the literature suggests that small, headwater streams rarely transport LWD long distances except during high magnitude floods or debris flows (MacDonald and Coe 2007). Debris flows can periodically move large pieces of wood from small headwater channels and hollows downslope to fish-bearing streams, where the wood can interact with the channel to form fish habitat (May and Gresswell 2003). Benda and Sias (2003) note that the fluvial wood transport rate is inversely proportional to the ratio of LWD length and channel width.

Specific answers to this question would require additional field study.

<u>Question 9 – Transport of LWD:</u> Do Class II watercourses with a bankfull channel width of 5-10 feet transport significant amounts of key piece size wood downstream to Class I waters (e.g. minimum 6" diameter x 1.5 length of receive Class I water channel width)? (CLASS II-L MINIMUM CHANNEL SIZE)

There is nothing this specific in the literature. Relevant literature includes Benda and Bigelow (2014), Jackson and Sturm (2002), and May and Gresswell (2003). See the response to question 8.

<u>References Cited</u>:

Benda, L. and P. Bigelow. 2014. On the patterns and processes of wood in northern California streams. *Geomorphology* 209: 79–97.

Benda, L.E., Litschert, S.E., Reeves, G. and Pabst, R., 2016. Thinning and in-stream wood recruitment in riparian second growth forests in coastal Oregon and the use of buffers and tree tipping as mitigation. *Journal of forestry research*, *27*(4), pp.821-836.

Benda, L.E. and Sias, J.C., 2003. A quantitative framework for evaluating the mass balance of in-stream organic debris. *Forest ecology and management*, *172*(1), pp.1-16.

Bladon, K.D., Segura, C., Cook, N.A., Bywater-Reyes, S. and Reiter, M., 2018. A multicatchment analysis of headwater and downstream temperature effects from contemporary forest harvesting. *Hydrological Processes*, *32*(2), pp.293-304.

Davis, L.J., Reiter, M. and Groom, J.D., 2016. Modelling temperature change downstream of forest harvest using Newton's law of cooling. *Hydrological Processes*, *30*(6), pp.959-971.

Erman, D. C., and F. K. Ligon. 1986. The response of algal communities in streams of the Jackson Demonstration State Forest to timber harvest activities. Final report submitted to California Department of Forestry. Sacramento, CA. 51 p.

Erman, D.C., J.D. Newbold, and K.R. Roby. 1977. Evaluation of streamside buffer strips for protecting aquatic organisms. Contribution No. 165, California Water Resources Center, University of California, Davis. 48 p.

Hardy, J.P. 2017. Spatiotemporal variability in the macroinvertebrate community of a small coastal California stream. Master of Science Thesis. Cal Poly State University, San Luis Obispo. 155 p.

Hassan, M.A., Hogan, D.L., Bird, S.A., May, C.L., Gomi, T. and Campbell, D., 2005. Spatial and temporal dynamics of wood in headwater streams of the Pacific Northwest. *JAWRA Journal of the American Water Resources Association*, 41(4): 899-919.

Hess, L.J. 1977. The effects of logging road construction on insect drop into a small coastal stream. Master of Science Thesis. Humboldt State University, Arcata, CA. 58 p.

Jackson, C.R., and C.A. Sturm. 2002. Woody debris and channel morphology in first- and second-order forested channels in Washington’s coast range. *Water Resources Res*. 38(9): art. no. 1177.

Kaylor, M.J. and D.R. Warren. 2017. Linking riparian shade and the legacies of forest management to fish and vertebrate biomass in forested streams. *Ecosphere* 8(6): 1-19.

Kibler, K.M. 2007. The influence of contemporary forest harvesting on summer stream temperatures in headwater streams of Hinkle Creek, Oregon. Master of Science Thesis. Oregon State University. Corvallis, OR. 98 p.

Kibler, K.M., A. Skaugset, L.M. Ganio, and M.M. Huso. 2013. Effect of contemporary forest harvesting practices on headwater stream temperatures: Initial response of the Hinkle Creek catchment, Pacific Northwest, USA. *Forest Ecology and Management* 310: 680–691.

Lancaster, S.T. and Grant, G.E., 2006. Debris dams and the relief of headwater streams. *Geomorphology*, *82*(1-2), pp.84-97.

Li, J. W. Gerth, J. Sobata, R. Van Driesche, and D. Bateman. 2013. Long-term studies of macroinvertebrate responses to harvest. Abstract and PowerPoint Presentation. Oregon State University, Corvallis. http://watershedsresearch.org/study/hinkle-creek

MacDonald, L.H. and Coe, D., 2007. Influence of headwater streams on downstream reaches in forested areas. *Forest Science*, *53*(2), pp.148-168.

Mahoney, D.L. and D.C. Erman. 1984. The role of streamside bufferstrips in the ecology of aquatic biota. Pgs. 168-177 in: Warner, R.E., and K.M. Hendrix, eds. *California Riparian Systems: Ecology, Conservation, and Productive Management.* Berkeley: University of California Press, c1984 1984. http://ark.cdlib.org/ark:/13030/ft1c6003wp/

May, C.L. and Gresswell, R.E., 2003. Large wood recruitment and redistribution in headwater streams in the southern Oregon Coast Range, USA. *Canadian Journal of Forest Research*, 33(8), pp.1352-1362.

Moore, R.D., Spittlehouse, D.L. and Story, A., 2005. Riparian microclimate and stream temperature response to forest harvesting: a review1. *JAWRA Journal of the American Water Resources Association*, *41*(4), pp.813-834.

Newbold, J.D., Erman, D.C. and Roby, K.B., 1980. Effects of logging on macroinvertebrates in streams with and without buffer strips. *Canadian Journal of Fisheries and Aquatic Sciences*, 37(7), pp.1076-1085.

Otis, T. 2007. Processes that influence the downstream propagation of heat in streams below clearcut harvest units: Hinkle Creek paired watershed study. Master of Science Thesis. Oregon State University. Corvallis, OR. 54 p.

Otis, T. and Skaugset, A.E. 2007. Downstream temperature impacts of harvest in the Hinkle Creek paired watershed Study. In: International Mountain Logging and 13th Pacific Northwest Skyline Symposium (p. 112).

Richardson, J.S. and Béraud, S., 2014. Effects of riparian forest harvest on streams: a meta-analysis. *Journal of Applied Ecology*, *51*(6), pp.1712-1721.

Roon, D. and J. Dunham. 2018. Spatial patterns of riparian shade, light, and stream temperature in response to riparian thinning in redwood headwater streams. Abstract. Oregon Chapter of the American Fisheries Society, 54th Annual Meeting, Eugene, OR.

March 13-16, 2018. http://orafs.org/wp-content/uploads/2017/10/2018-Annual-Meeting-Abstracts.pdf

Scott, D.N., Montgomery, D.R. and Wohl, E.E., 2014. Log step and clast interactions in mountain streams in the central Cascade Range of Washington State, USA. *Geomorphology*, *216*, pp.180-186.

Svendsen, C.R., Quinn, T., Kolbe, D. and Light, S.C., 2004. Review of macroinvertebrate drift in lotic ecosystems. *Final Report. Seattle, WA: Wildlife Research Program, Environmental and Safety Division*.

SWC (Sound Watershed Consulting). 2008. Scientific literature review of forest management effects on riparian functions for anadromous salmonids. Final Report prepared for California State Board of Forestry and Fire Protection. Sacramento, CA. 328 p.

Wick, A.R. 2016. Adaptive management of a riparian zne in the lower Klamath River Basin, northern California: the effects of riparian harvest on canopy closure, water temperatures and baseflow. Master of Science Thesis. Humboldt State University. Arcata, CA. 102 p.

Wilcox, A.C., Peckarsky, B.L., Taylor, B.W. and Encalada, A.C., 2008. Hydraulic and geomorphic effects on mayfly drift in high-gradient streams at moderate discharges. *Ecohydrology*, *1*(2), pp.176-186.

Wilzbach, P. and K. Cummins. ND. Riparian management and fish productivity. PowerPoint presentation. USGS CA Cooperative Fish Research Unit Humboldt State University, Arcata, CA.

Wilzbach, M.A., Harvey, B.C., White, J.L. and Nakamoto, R.J., 2005. Effects of riparian canopy opening and salmon carcass addition on the abundance and growth of resident salmonids. *Canadian Journal of Fisheries and Aquatic Sciences*, 62(1), pp.58-67.

Wipfli, M.S. and Gregovich, D.P., 2002. Export of invertebrates and detritus from fishless headwater streams in southeastern Alaska: implications for downstream salmonid production. *Freshwater Biology*, 47(5), pp.957-969.

Yeung, A.C., Lecerf, A. and Richardson, J.S., 2017. Assessing the long-term ecological effects of riparian management practices on headwater streams in a coastal temperate rainforest. *Forest Ecology and Management*, *384*, pp.100-109.